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CONTRIBUTIONS TO OUR KNOWLEDGE OF MICRO-ORGANISMS AND STERILIZING PROCESSES IN THE CANNING INDUSTRIES.

In a paper read before the Society of Arts in October, 1896,* we showed the extent of the canning industry in this country, and the importance to it of accurate knowledge of the bacteriological principles of sterilization. In that paper we dealt with the packing of clams and lobsters, and described some of the bacteria which are active in the deterioration of these products in case sterilization is not complete. It is interesting to notice that some of the results which we published at that time have lately been confirmed by a specialist employed by the Canadian government† to investigate the discoloration of canned lobsters.

We now desire to put on record a preliminary account of our more recent investigations in another branch of the industry, viz., the packing of sweet corn. This art constitutes a very large industry, as is shown by the fact that in 1895 72,000,000 two-pound cans (72,000 tons) were packed in the United States. The growth of the business has been rapid, for it was not until about 1853 that corn was packed at all with success.

Sweet corn, when properly prepared, is one of the most valuable of all canned foods, as it retains much of its original flavor, is popular, and is sold at a price within the reach of all. If, however, the sterilizing has not been thoroughly done there may result fermentations caused by bacteria which have not been killed, producing what is known as 'sour' corn.

Our investigations commenced in February, 1897, with the examination of a large number of cans of sour corn. On opening the cans no change was noticeable to the eye, the corn appearing fresh and of a natural color. In some cases a sour odor could be detected, but in others this was not observed. It was to the taste that the trouble was most apparent, the corn being sour and of a peculiar, astringent flavor. Bacteriological examinations showed sound cans to be sterile, while spoiled cans invariably gave evidence of bacterial action. Pure cultures of six species were obtained, of which five were bacilli, and one was a micrococcus. By inoculating sterile cans of corn with these organisms we have been able to produce souring in all respects similar to that of the spoiled cans from which they were originally taken.

In order to study these fermentations more thoroughly and to ascertain, if possible, the source of the bacteria causing them, we spent nearly the whole of the corn-packing season of 1897 at an establishment in Oxford county, Maine, where every convenience for scientific study of the process was put at our disposal by the proprietors. We were thus enabled to thoroughly investigate the methods of procedure from the harvesting of the green corn to its ultimate shipment in cans. It is very necessary that the utmost cleanliness and dispatch should be observed in all the operations, so that the chances of infection from bacteria may be reduced to a minimum. In this factory the strictest caution was exercised in these respects, everything being kept scrupulously clean.

The corn is generally picked in the morning, and is delivered to the cannery as early as possible. One or two men make it their special duty to visit the farms once or twice a week during the season to keep informed as to the condition of the crop and to 'order in' the corn as it becomes sufficiently matured. As the ears are delivered at the factory they are arranged in low piles on the ground in an open shed to protect them from the sun. The husks and the silk are

* Technology Quarterly, Vol. X., No. 1.

† Supplement No. 2, 29th Annual Rep't, Department of Marine and Fisheries, Ottawa, 1897.

taken off by hand, and the corn is then quickly carried to the cutting machines, in which, by a series of knives and scrapers, the kernels are quickly and cleanly separated from the cob. Any stray bits of cob or silk which may be mixed with the corn are now taken out as it passes through the 'silker,' a machine arranged somewhat on the plan of a gravel-sifter, that is, with two cylindrical wire screens one inside the other, placed on an incline and rotating in opposite directions. The corn drops through the meshes of the screens, while the refuse passes out at the lower (open) end.

The corn is now weighed, mixed with water in the proper proportions, and is then ready for the 'cooker.' There are several varieties of these machines in use, all of which are alike in principle but differ somewhat in details of construction. Their object is to heat the corn evenly and quickly to a temperature of 82–88° C. (180–190°F.) and to deliver it automatically into the cans. A single machine fills about thirty cans a minute. After having been wiped, the cans are capped, soldered and tested for leaks. Sterilization, the final and most important step in the whole process, now follows, this being done in retorts, by steam under pressure. The length of heating, or 'processing,' and the pressure which is given vary somewhat in different factories.

As we have shown in our previous paper, in order to insure sterilization in practice, it is necessary to obtain and maintain a temperature in excess of 100° C. (212° F.) throughout the contents of the can. Intermittent sterilization may be employed, but is less efficient and is not practicable upon a large or commercial scale. We have found by experiment that sixty minutes at 121° C. (250° F.) is sufficient time for sterilizing corn, and it seems probable that this can be shortened somewhat or the temperature reduced. Further experiments are in progress to decide this question.

Through a demand that canned corn shall be very light in color there has been, apparently, a pressure put upon the packer to shorten the time of heating or to reduce the temperature in his retorts. The large losses which have resulted in recent years from sour corn have been due principally to this demand. By the use of registering thermometers we have proved that corn is a very poor conductor of heat, and that the time necessary to bring all portions of the center of the cans to the requisite temperature is a factor whose importance cannot be overestimated. We have proved by experiment that, with 13 pounds of steam in the retort, the corresponding temperature of which is 118.8° C. (246° F.), it requires 55 minutes for the same temperature to be registered at the center of a can placed in the middle of a retortful of corn. With the same pressure and under the same conditions at the end of 45 minutes a temperature of 114° C. (237.2° F.) was reached, and at the end of 30 minutes 108.3° C. (227° F.). Thus it is evident that with the present methods any reduction of time of heating is attended by considerable risk. If any means could be devised by which the heat would more quickly reach the center of the cans it might be safe to shorten the time of heating. There is a prospect that before long some such modifications may be possible.

We have made a careful bacteriological study of all the different steps in the process and of the corn as it comes from the field, and have found upon the corn in the field bacteria which appear to be identical with those isolated from cans of sour corn. Repeated tests of corn from the cob showed the presence of bacteria. Corn which had passed through the cooker, and cans of corn which had been 'retorted' for 30 minutes or less, also contained the same species of bacteria as were found upon the raw corn.

All these bacteria liquify gelatin, and

grow very rapidly, as is proved by the fact that streak cultures showed well marked growth four hours after inoculation. Detailed descriptions of the organisms and of many more experiments will be given in our full paper on this subject to appear in a forthcoming number of the *Technology Quarterly*.

S. C. Prescott,
W. Lyman Underwood.
Biological Laboratory, Mass. Institute of Technology.
Boston, November 12, 1897.

AMERICAN ORNITHOLOGISTS' UNION.

The Fifteenth Congress of the American Ornithologists' Union convened in New York City, Monday evening, November 8th. The public sessions, lasting three days, were held in the library of the American Museum of Natural History.

William Brewster, of Cambridge, Mass., was re-elected President; Dr. C. Hart Merriam and Robert Ridgway, of Washington, D. C., Vice Presidents; John H. Sage, of Portland, Conn., Secretary; William Dutcher, of New York City, Treasurer; Charles F. Batchelder, Frank M. Chapman, Chas. B. Cory, Ruthven Deane, Drs. Jonathan Dwight, Jr., A. K. Fisher and L. Stejneger, members of the Council. By a provision of the by-laws, the ex-Presidents of the Union, Dr. J. A. Allen, Dr. Elliott Coues, and Mr. D. G. Elliot, are *ex officio* members of the Council.

One active and eighty-eight associate members were elected. As a direct result of the Audubon Society movement, creating a popular interest in the study of birds, more women than usual were elected to associate membership.

An address in commemoration of Major Charles Emil Bendire, U. S. A., a distinguished member of the Union who died during the past year, was prepared by Dr. J. C. Merrill, U. S. A., and presented by Mr. Elliot. Major Bendire was a well-known oologist, and will always be remembered by his invaluable 'Life Histories of North American Birds.'

Dr. Coues exhibited the portfolio carried by John James Audubon in Europe and America, and also the original MS. of the first volume of his 'Ornithological Biography.' Some original bird-drawings by John Woodhouse Audubon were also shown.

Mr. Abbott H. Thayer, the eminent portrait painter, gave an out-of-door demonstration of the underlying principle of protective coloration, in continuation of his remarks on the subject at the previous meeting. Mr. Thayer showed a pair of decoys with the belly part cut off, so that in lying on the cut-off side they represented crouching birds or mammals. He then repeated upon them the coloring which he had exhibited at Cambridge upon entire decoys (decoys poised a few inches above the ground). This, he said, was to more clearly illustrate what he stated in his first paper on protective coloration, namely, that the normal gradation of sky's lighting is effaced *by the color gradation of the animal at every point*, the median dorsal line having the darkest markings, so that the gradation toward the white of the belly *begins close to this dorsal line*. Mr. Thayer placed the two decoys side by side on a plank, and covered one of them uniformly with the same dry earth which he spread about it on the plank, so that all of its visible surface and that of the plank on which it lay were absolutely of one tint—monochrome; yet it was conspicuously visible at a long distance, because of its normal gradation of shading from the sky's light, although there was no underside visible to show a culmination of shadow. The other decoy he painted in imitation of a hare's or snipe's gradation and so successfully that it became totally invisible at a distance of four or five yards. He explained that the statement in his first paper